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PRINTER OPERATING CHARACTERISTICS CHART

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Printer Operating Characteristics Chart

Abstract: Raw device telemetry data is converted into intelligible failure signatures of individual parts via a graphical representation of telemetry sequences in order to generate actionable failure prediction and diagnosis.

This disclosure relates to the field of electronic devices, and more specifically, printers.

A technique is disclosed that converts raw device telemetry data into intelligible failure signatures of individual parts via a graphical representation of telemetry sequences.

In some configurations, an individual printer can output a stream of telemetry data. This includes failure signatures of various printer components, and can be used to forecast part failures. However, the raw stream of data consists of disjoint events, and is unintelligible for failure prediction purposes. This is so because failure signatures are not disjointed events, but rather sequences of printer events taken together, in context. An example of a failure signature that forecasts fuser failure is two fuser temperature spikes combined with rapid succession of 30 fuser paper jams.

According to the present disclosure, and as indicated in the Figures, raw telemetry data is compressed down to such failure signatures. This may be done by an Integer Continuity Compression (ICC) algorithm. The input is raw telemetry events from many printers, as depicted in chart 10, representing in this example approximately 60,000 data points. Each of these events is marked in black or gray, corresponding to the printer being in either a healthy or an unhealthy state respectively during the event. Several example healthy events 12 and unhealthy events 14 for various printers are denoted on chart 10.

By applying the ICC algorithm to the raw telemetry data, a Printer Operating Characteristics Chart (POCC) 20 is output which assigns an id to each printer, and collapses the printer's events to failure signatures. Non-failure signatures are illustrated in black, while failure signatures are illustrated in gray. In chart 20, for a particular printer "V", a black healthy (non-failure) signature 22 and a gray (failure) signature 24 are indicated. The healthy (non-failure) signature 22 may be generated for ten paper jam events occurring in rapid succession combined with one thermal spike that did not cause failure, while the gray (failure) signature 24 may be generated for five fuser temperature spikes in rapid succession combined with two fuser paper jam events. This would lead to the conclusion that for printer "V", the fuser failure is predominantly thermal in nature. Thus, the failure signatures are made intelligible to human analysts, on an individual printer basis.

The ICC algorithm is specifically tailored for the printer telemetry data, and operates as follows:

- 1) Raw telemetry data is read.
- 2) Rolling Count Sequences are formed.
- 3) Each Elbow Point (EP) is marked.
- 4) The maxima and minima of EP (referred to as Extreme EP, or EEP) are marked.
- 5) A brute force analysis is performed on the EEPs to get the Sequence Pareto Points.

A further step of smoothing combines individual printer failure signatures to agglomerative failure signatures across multiple printers. Now each failure signature 32

may be marked in varying shades of gray in an Agglomerative POCC chart 30, in which the particular shade of each signature 32 indicates how likely (on an agglomerative basis) that signature 32 is to trigger fuser failure. This enables drawing of a decision boundary 34 which provides failure predictions and part replacement recommendations. For example, to the right of the boundary 34, fuser failure is imminent and the fuser should be replaced.

The disclosed technique advantageously predicts part failures before they occur, which enables service optimization by allowing enhanced inventory planning, fleet scheduling, and optimal part replacement. It also enables actionable failure predictions and better insight into failure modes of parts, which in turn leads to better failure diagnosis. The charts are rich in intuition and readily communicate underlying failure mechanisms. As such, the technique equates to both cost and time savings via the service optimizations.

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